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A Study of the Effects on Pupil Achievement of Certain Audio and Visual Presentation Sequences. Final Report.

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An investigation was made to determine whether pupils learn more when sight and sound are not presented simultaneously, and whether audio or visual redundancy cause a cueing effect which produces a superior sight-sound or sound-sight sequence. Commercially produced filmstrip lessons were converted into two experimental and two control sequences for the investigation, and subsequent findings were as follows: pupils in fact learn less when sight and sound are not presented simultaneously; and as to cueing, there are no conclusive answers. A significant "by-product" finding was that the common practice of using audiovisual lessons with several grades and pupils of varying mental ability may be very inefficient. This would imply a need for pretesting audiovisual materials to give teachers better guidance regarding their use. A bibliography is appended. (GO)

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A STUDY OF THE EFFECTS ON PUPIL ACHIEVEMENT OF CERTAIN AUDIO AND VISUAL PRESENTATION SEQUENCES

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FINAL REPORT

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ABSTRACT

A Study of the Effects on Pupil Achievement of Certain Audio and Visual Presentation Sequences

Purpose: The purpose of the investigation was to determine if:

(1) A given group of pupils gain more information from slide-tape audio-visual materials when sight and sound are not presented simultaneously.

(2) Audio or visual redundancy of information cause cueing effects which will produce a superior sight-sound or sound-sight sequence in conveying information to pupils.

Previous investigations have indicated that crowding a person's communication channels reduces ability to attend. It has also been found that cueing and attention focusing are important in pupil learning. It is hypothesized, therefore, that:

(1) Separating the picture and sound of a slide-tape lesson would improve pupil information acquisition and

(2) If filmstrip-tape lessons are designed to present information in differing audio-visual sequences, cueing and attention effects will produce differences in how much pupils learn from the medium.

Method: Commercially produced filmstrip lessons were converted into two experimental and two control sequence modes of presentation in terms of information frames:

(1) An experimental treatment in which each picture was preceded by the audio (A—►V) and another in which each picture preceded the audio (V—►A).

(2) A control treatment in which audio and visual were simultaneous but with time pauses between information frames to duplicate the total time which elapsed for the experimental modes (A-V Pause); and another control with the usual A-V sequence. Some of the lessons were audio redundant; i.e., most of the information was given visually with audio merely duplicating visual information. In other lessons, the conditions were such as to produce visual redundancy.

Findings and Conclusions: The original hypothesis, based on previous studies of human perception, that sight-sound sepatation would produce better pupil information acquisition than the control conditions of simultaneous sight-sound, was abandoned after a pilot study. The reverse hypothesis, that simultaneous sight-sound would prove superior to sight-sound separation, proved correct.

Tests of hypotheses regarding A→V or V→A sequencing in terms of redundancy cueing effect did not produce conclusive results.

A significant "by-product" finding of the experiments conducted revealed that the common practice of using audio-visual lessons with several grades and pupils of varying mental ability may be very inefficient. This would imply a need for pre-testing audio-visual materials to give teachers better guidance regarding their use.

SECTION I

THE PROBLEM AND OBJECTIVES OF THE STUDY

Purposes of the Study

The purpose of the study was to determine if different methods of sequencing audio and visual portions of a teaching medium would result in differences in pupil information acquisition. Specifically, answers to the following questions were sought:

(1) Do pupils learn more from certain audio-visual materials when sight and sound are not presented simultaneously?

(2) Does audio or visual redundancy of information cause a cueing effect which will produce a superior sight-sound or sound-sight sequence in conveying information to pupils?

Two experimental and two control sequences, using slide-tape presentations, were studied:

(1) An experimental mode in which each bit of audio information was followed by the corresponding visual frame (A ➞ V).

(2) An experimental mode in which each visual frame was followed by the corresponding audio (V ➞ A).

(3) A control mode in which audio-visual frames occurred simultaneously as in a normal audio-visual lesson but with no information pauses between the frames to give a total time for the lesson equal to the first two types of sequences (A-V pause).

(4) The normal audio-visual control sequence (A-V) in which audio-visual information frames follow one another in succession.

The purpose served, and specific objectives sought by the experiment were associated with the whole question of perception which has been studied by psychologists for many years. The function of set in perception, for example, is discussed extensively in the literature of psychology. This is also true of the act of attending. In summarizing such studies, Solley and Murphy (5) point out that: "There can be little doubt that what we perceive is (in part) determined by. . . . . the potentiation of one set of factors by another." If this is accepted, then it is logical to hypothesize that the sequence in which individuals receive audio and visual stimulation may have some bearing upon how much they perceive; and therefore, how much they learn. In other words, sequence of communication modes may be considered to be "factors" which "potentiate."

The notion that various methods of sequencing audio-visual messages may bring about differences in learning seems to fit the Broadbent (1) model of the human perceptual system. The model, used by Broadbent and others to guide experiments in perception, represents the human receiver of information as one which operates with but one communication channel open at a given time. Travers, et al, (6) in reviewing research and theory related to information transmission through audio-visual methods, concluded ". . . . . the Broadbent model suggests that auditory word presentation should not occur simultaneously with the visual object presentation . . . . . While the model does not indicate whether succession should be audio-visual or visual-auditory, other information from experimental psychology suggests that order may be important."

But what are the factors which make audio-visual sequence important; and is the same sequence always superior? An answer to this question may be found in some experiments in audio-visual education conducted by Nue (4) and also May and Lumsdaime (3) among others. The studies indicate that perception is a function of cueing. Cueing results when the information supplied through one communication channel is used primarily as a method to focus attention upon what is presented through another.

Audio-visual materials used for classroom instruction such as filmstrip with recording, sound films, and television generally have some information which is audio-visual redundant; i.e., the information is presented through both the audio and the visual communication channels. Presumably, the purpose served by the repetition is to focus the attention of the learner on particular points. In proposing the research which this report describes, it was reasoned that experiments which combine attention focusing, through audio-visual redundancy, with audio-visual sequencing, might be productive of new knowledge regarding human information acquisition through A-V materials.

Operational Definitions and Hypotheses

Two definitions, which were adopted for the study, will help clarify the hypotheses presented later in this section:

a. Audio redundant lesson--an audio-visual lesson in which most of the information presented is to be found in the visuals with the audio merely repeating a portion of the visual information.

b. Visual redundant lesson--an audio-visual lesson in which most of the information presented is to be found in the audio with visuals merely repeating a portion of the audio information.

From the theoretical considerations which have been discussed, three hypotheses were originally developed to guide the study. The Broadbent model of perception suggested the first; the second and third, which were the reverse of each other, were proposed in order to determine if audio-visual redundancy produces a cueing effect.

It was hypothesized that if pupils were presented lessons in the sequence modes described as A→V, V→A, A-V pause, and A-V,

1. the experimental modes (A→V and V→A), which separate sight and sound, would result in greater pupil information acquisition than the control modes (A-V pause and A-V) which present the visual and audio message simultaneously.

2. a lesson which is audio redundant would produce audio cueing to visuals which would result in A→V experimental mode being superior to V→A experimental mode as a method of conveying information.

3. a lesson which is visual redundant would produce a visual cueing effect which would result in V→A mode being superior to A→V as a method of conveying information.

SECTION II

THE PILOT STUDIES

The original project proposal called for each of two commercially produced filmstrip lessons to be converted to slide-tape presentations. The criteria for the selection of the particular filmstrips were:

1. Suitability of the lessons for the intermediate grades (as listed in <u>Education Media Index</u>, Vol. 2, <u>Intermediate Grades</u>); and

2. The lessons were to cover subject matter to which the pupils had had a minimum exposure.

In the first set of experiments, each lesson was prepared in the A→V, V→A, A-V (pause) and A-V sequence modes. In the A→V and also V→A sequence modes, a blank, grey-colored slide appeared during the audio presentations. With the A-V pause mode, the blank slide appeared during each pause. This procedure was adopted to get around the problem of having pupils distracted by an alternating dark and lighted screen.

The A-V (pause) and A-V sequences were to serve as controls in determing the validity of hypothesis one since both of these sequences presented audio and visual frames simultaneously in contrast to the experimental modes which separated sight and sound. A-V pause produced a sequence equal in time to the experimental sequences A→V and V→A. The A-V mode was to provide the ordinary way of presenting a slide tape lesson. Tests of A→V groups performances versus V→A groups were used to evaluate hypothesis two (audio redundancy would make A→V superior) and hypothesis three (visual redundancy would make V→A the superior sequence).

One of the lessons was to have a great deal of information given in the visuals with the audio merely providing some information that was already present in the visuals. The second lesson was to have much information in audio form, with visuals repeating a portion of that provided in the audio. Figure 1 represents the two conditions in the form of Venn diagrams. The set of total information provided by each lesson is shown as a large circle. The redundant information (the subset) is shown as a smaller circle within the larger.

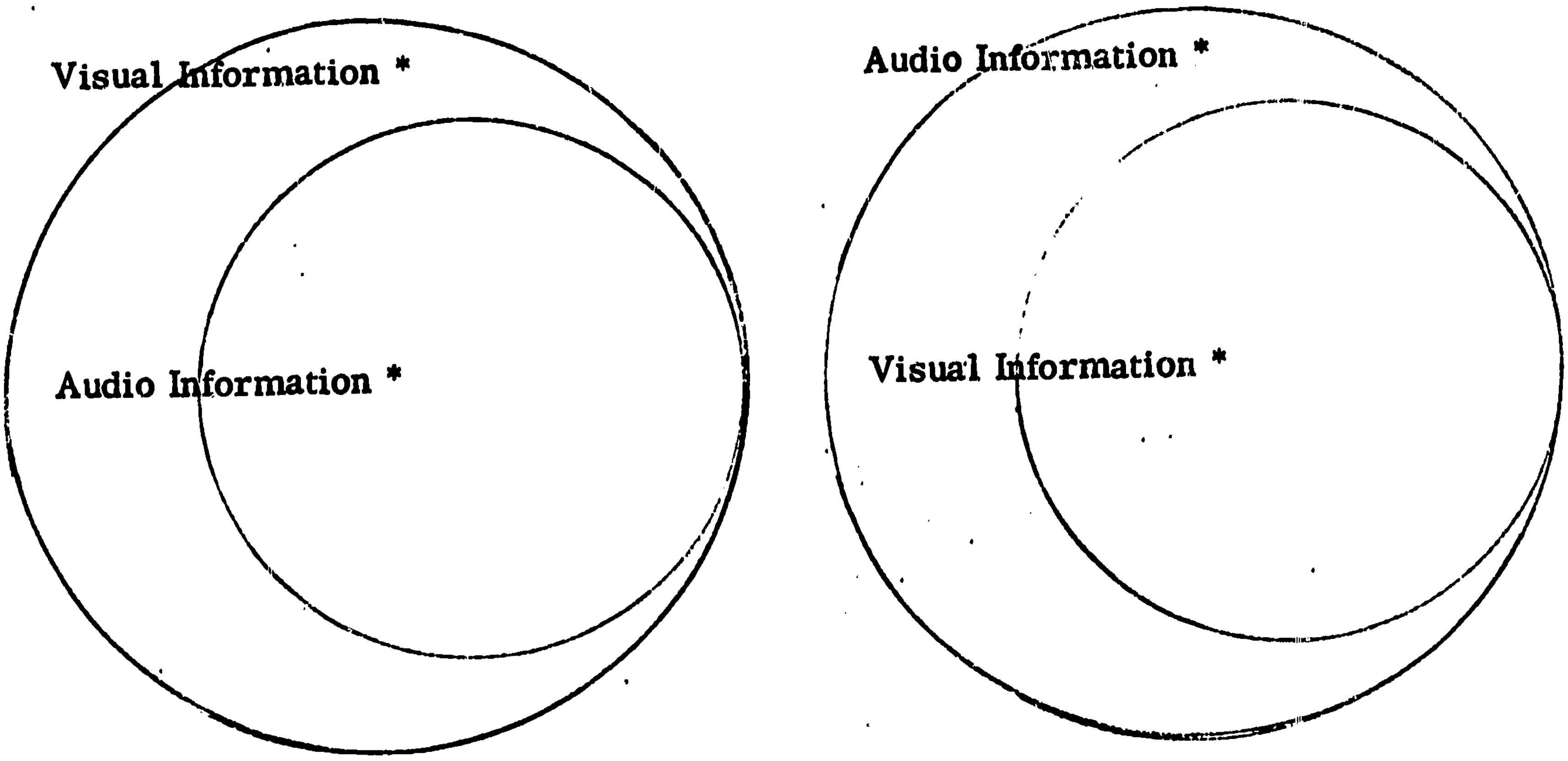


Figure 1

Filmstrip-Tape Lesson 1
(Audio redundant)

Versions of Lesson 1 were:
A→V and V→A
A-V pause and A-V

Filmstrip-Tape Lesson 2
(Visual redundant)

Versions of Lesson 2 were:
A→V and V→A
A-V pause and A-V

The project was started in the fall of 1967 through a review of the catalogue descriptions of approximately seventy-five filmstrips appropriate for use in the intermediate elementary grades. Eighteen filmstrips were obtained for appraisal by intermediate grade teacher-judges; of these, eight were purchased for more careful study. (Audio scripts to go along with the filmstrips were available with the materials purchased.)

The two audio-filmstrips selected for the project were: "The Stars and Outer Space" and "The People of Rome." Both sound filmstrips were distributed by the Society for Visual Education, Inc., of Chicago, Illinois.

With minor changes in the script for the audio portion of "The Stars and Outer Space," an attempt was made to develop it into a primarily visual, "audio redundant," lesson; "The People of Rome" was made into a largely audio, "visual redundant," lesson.

Criterion instruments in the form of multiple-choice objective tests were prepared. Sixty items made up the original test on information from "The People of Rome," and fifty-seven for "The Stars and Outer Space."

In a pilot study conducted with intermediate grade children in the Lee Hall Elementary School, Newport News, Virginia each of two groups of thirty randomly selected pupils was presented one of the lessons in the ordinary fashion; i.e., filmstrips with sound. The children were administered the tests and an item analysis was used to make improvements in the test construction. The procedure resulted in a forty item test for each lesson.

The validities of the revised tests based on the two lessons were determined by administering the tests to another randomly selected group of sixty-four intermediate grade pupils from the same school; these pupils were not exposed to the lessons. Thirty-two of the pupils tried the test on "The Stars and Outer Space" and thirty-two tried the test on "The People of Rome." A t-test of means scored on the forty items tests by random groups of pupils who were exposed to the lessons, as contrasted to those who were not, showed the results as listed in Table I.

Table I

Pilot Study (Exposed Group vs. Not Exposed Group)
t-tests of Means

Lesson	Means (Exposed Group)	Means (Not Exposed Group)	t-ratio
The Stars and Outer Space	25.52	16.19	5.36*
The People of Rome	26.81	12.47	9.69*
*Significant at the 1% level			

From Table I it can be seen that pupils who received the lessons did indeed acquire a measureable quantity of information beyond what they might know about each subject before seeing the lessons.

After the validation of test items, the pilot study was continued in the Lee Hall Elementary School, with a "dress rehearsal" of the experiments that were to be conducted in the Hampton City School System, Virginia. Randomly selected groups of pupils were assigned to receive the lesson "The Stars and Outer Space" as presented in various sequence modes, and other randomly selected groups of pupils were given the lesson "The People of Rome" in the various sequences. No single pupil saw more than one sequence of one lesson. The method used for each experimental lesson employed a grade level by treatment statistical design with eight pupils per level and treatment as shown in Table II.

Table II

Experimental Design -- Pilot Study

Grade Level	Treatment Mode			
	A→V	V→A	A→V (pause)	A-V
4	8	8	8	8
5	8	8	8	8
6	8	8	8	8
7	8	8	8	8
	N = 128			

Thus, one group of 128 pupils took part in experimental lesson number one which was carried out with the audio redundant "The Stars and Outer Space, " and a different group of 128 took part in experimental lesson number two which used the visual redundant "The People of Rome. "

Analysis of the results of the pilot study produced the results shown in Table III.

Table III

Analysis of Variance -- Pilot Study
Lee Hall School

Source of Variation	Sums of Squares	df	Mean Square	F-ratio
Lesson 1 "The Stars and Outer Space" (audio redundant)				
Treatment T	39	3	20	.43
Grade G	634	3	211	4.73*
T x G Interaction	723	6	121	2.71*
Error	3747	84	45	
Lesson 2 "The People of Rome"(visual redundant)				
Treatment T	516	2	258	4.78*
Grade G	201	3	67	1.24
T x G Interaction	73	6	12	.22
Error	4566	84	54	

* Significant at the 5% level
** Significant at the 1% level

Lesson 1 t-ratio (experimental versus controls) = 1.65 (not significant but control means higher than experimental)

t-ratio (A $\rightarrow$ V versus V $\rightarrow$ A) = .46 (not significant)

Lesson 2 t-ratio (experimental versus controls) = 1.91 not significant but with control means higher than experimental

t-ratio (A $\rightarrow$ V versus V $\rightarrow$ A) = 2.73 (significant a 1% level)

The results were confusing, in terms of the original hypotheses. The control treatment means in all cases were as high or higher than experimental means--casting doubt on hypothesis one; and although in lesson #2 V→A proved superior to A→V as anticipated, the inverse hypothesis was not supported in lesson #1. Further, the interactions between levels and sequences modes were significant for both experiments. It was decided these results might indicate a "wash out" of experimental differences in the case of lesson #1 due to difficulty encountered by lower grade children with the lesson and the test. Experiments with the two lessons, scheduled for the Hampton, Virginia School System, were therefore changed to include only pupils in grades 7, 8, and 9. Pilot study experiments conducted in Hampton City schools were essentially the same as the pilot project at the Newport News Lee Hall Elementary School. Two-hundred and sixty-four pupils from seven different junior high schools were selected at random and divided into two groups of one-hundred and thirty-two each. The first group was assigned to view the audio redundant lesson 1--"The Stars and Outer Space," the second group saw the visual redundant lesson 2--"The People of Rome."

Forty-four different pupils represented each of the three grade levels in the experiments. The design for the experiments is shown in Table IV. As with the Newport News pilot study, a pupil was exposed to but one sequence version of one lesson as a precaution against confounding the results with treatment carry-over effects.

Table IV

Experimental Design - Preliminary Experiments

Grade Level	Treatment Mode			
	A→V	V→A	A→V (pause)	A-V
7	11	11	11	11
8	11	11	11	11
9	11	11	11	11
	N = 132 with 44 per grade for each experiment			

A partial analysis of the performance of the Hampton pupils who took part in the experiments are shown in Table V.

Table V

Analysis of Variance - Pilot Study
Hampton School System

Source of Variation		Sums of Squares	df	Mean Square	F-ratio
Lesson 1 "The Stars and Outer Space" (audio redundant)					
Treatment	T	15	3	5	.14
Grade	G	291	2	145	4.08*
T x G Interaction		122	6	20	.57
Error		3914	120	36	
Lesson 2 "The People of Rome" (visual redundant)					
Treatment	T	479	3	160	3.93*
Grade	G	251	2	126	3.09*
T x G Interaction		392	6	65	1.61
Error		4874	120	41	

* Significant at the 5% level
** Significant at the 1% level

Lesson 1 t-ratio (experimental versus controls) = .43 (not significant)
t-ratio (A—►V versus V—►A) = 1.46 (not significant)

Lesson 2 t-ratio (experimental versus controls) = 2.16 (significant at the 1% level with control means exceeding experimental as shown below)

	A—►V	V—►A	A-V Pause	A-V
Lesson 1	30.42	29.54	30.21	29.87
Lesson 2	24.87	20.09	29.69	29.02

Again the results appeared to be inconclusive in terms of the original hypothesis number two and its inverse number three since no significant differences were found among the treatment groups in the audio redundant lesson but a significant F-ratio showed up in the visual redundant lesson.

Further analysis of individual group performances on the experiment with the visually redundant "The People of Rome" in both the elementary school pilot study and the experiments with junior high school pupils had produced more puzzling results. In both the pilot study and Hampton experiment, V→A and the control, A-V and A-V (pause), groups performed equally well, but group scores for A→V were so low as to produce the significant F among treatments. A comparison of the means scored by pupils exposed to A→V and V→A produced a t-ratio of 2.57 which has a random probability of less than .02.

At this point in the research, it appeared that either hypothesis number two was incorrect and hypothesis three was correct, or that experimental conditions had produced so much variance in the experiment with Lesson 1 ("The Stars and Outer Space") that type II error was made in not rejecting the null hypothesis. Assuming experimental error might be the source of the conflicting results, but that hypothesis three might indeed be correct even though its inverse was not, it was decided that another experiment should be designed. Also important, however, the high performances of the control groups made it appear possible that the reverse of hypothesis one might be true.

It was reasoned that the new experimental design should:

(1) Incorporate an attempt to reduce error variance by using an additional assigned factor--ability level;

(2) Limit the experiment to a single slide-tape lesson which need not be classified as either primarily audio redundant or visual redundant; and

(3) Evaluate the results of the new experimental lesson in terms of a test made up of three types of items--audio information, visual information, and audio-visual information.

Step number two above allowed for a control of the lesson variable; a single lesson instead of two being used to test the hypotheses. Step number three was taken as an attempt to control the amount of redundancy through the test items used. By combining audio information scores with audio-visual information scores, the total lesson information was made largely audio with visuals redundant. The combination of visual information with audio-visual information would produce a largely visual lesson with audio redundancy.

SECTION III

DESIGN OF THE FINAL EXPERIMENT

The results of the pilot studies indicated that alternative hypotheses should be tested. Hypothesis one, that the experimental modes would prove superior to the control modes had been based upon Travers' (6) discussion of the Broadbent model of perception. Travers' interpretation had suggested that. . . . . "auditory word presentation should not occur simultaneously with the visual object presentation. . . . ." Experiments with the first two lessons, however, had indicated that both control modes (A-V pause and A-V) had given results equal to, or in one case superior to, one of the experimental modes. Further, the experiments seemed to show that the A→V mode might tend to suppress information acquisition when the visuals were the predominant method of conveying the lesson (as in Lesson II--"The People of Rome).

The following three hypotheses, therefore, were formulated for testing in the final experiment:

(1) If an audio-visual lesson is presented in the A→V and V→A (experimental) modes, which separate sight and sound, and also in the A-V pause and A-V (control) modes, in which sight and sound are presented together, pupils will gain more information from the simultaneous sight and sound modes than from the modes which separate the audio and visual messages.

(2) There will be no significant difference between the amount of information gained by pupils through the two control modes A-V pause and A-V.

(3) If pupils are to acquire information from an audio-visual lesson in which information is primarily from an audio source, pupils will gain more from the V→A mode than from an A→V mode of presentation.

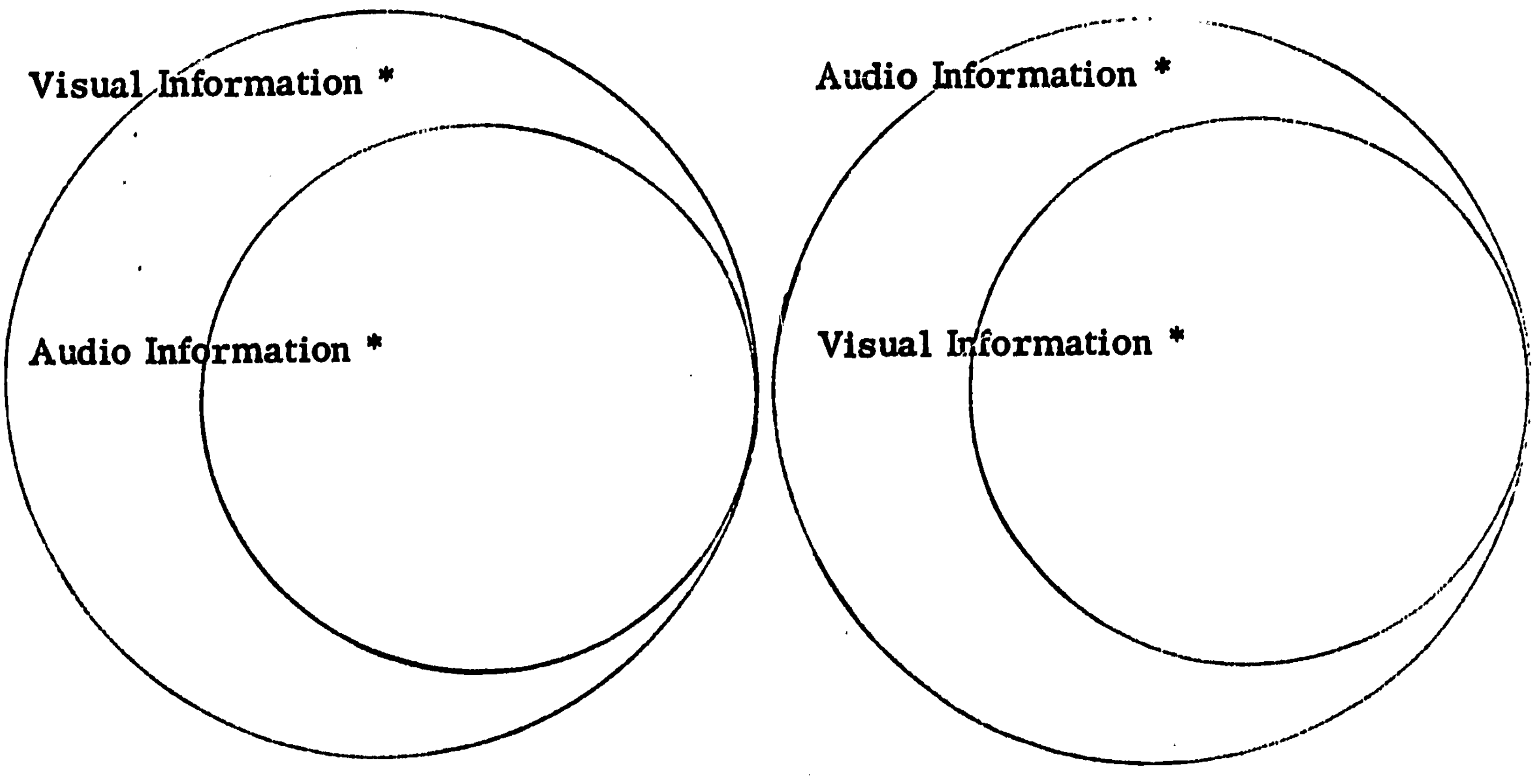
Procedure

For the final experiment, additional filmstrips were appraised in terms of three criteria: (1) suitability for the junior high school grades; (2) subject matter not familiar to the groups who were to take part in the study; and (3) information presented in approximately equal proportion as strictly audio, strictly visual, and both audio and visual. The lesson selected was part of a series on the geography of Africa--The Eastern Highlands--produced by the Society for Visual Education. It consisted of sixty-three information frames.

As in the pilot studies, factors such as the time of day when lessons were presented and the physical setting were carefully controlled. Also, the audio for all sequence modes was originally made into a master tape by a professional announcer; the tapes for the various lessons were thereby the same except in terms of the sequence mode of presentation.

The evaluation instrument consisted of a 120 item multiple choice test. Forty items came from the audio source of information, forty from visual source of information, and forty were selected in terms of information that was presented by both sight and sound. (For obvious reasons, however, the various types of items were mixed together at random throughout the test.)

The test was prepared in this threefold form as an attempt to control and analyze pupil information acquisition in terms of the specific percept source or sources. It was felt that by combining scores from the audio source, and also those which were from the solely visual source, with the information which was presented in both audio and visual form the conditions shown in Figure 2 would be created without having to resort to two different slide-tape lessons as in the pilot study experiments.



Students who were to take part in the experiment were selected from the eighth and ninth grade in two school systems which had not been involved in the original study: the Williamsburg-James City County System, and the York County System of Tidewater Virginia.

The mental ability of all eighth and ninth graders in the Berkeley Junior High School of the Williamsburg-James City County System, and the Queens Lake Junior High School of York County were recorded and separated into three categories: high ability (117 or higher IQ), average ability (90-110 IQ), and low ability (85 or lower). Since the criterion test was to be administered in written form, pupils with a reading level below grade four were excluded. Forty-four high ability students, forty-four of average ability, and forty-four of low ability from each grade were selected at random to take part in the study and assigned at random to the treatment groups as shown in Table VI.

Table VI

Experimental Design - Final Experiment

Ability Level	Treatment Mode							
	A→V		V→A		A-V (pause)		A-V	
	grade		grade		grade		grade	
	9th	8th	9th	8th	9th	8th	9th	8th
High	11	11	11	11	11	11	11	11
Average	11	11	11	11	11	11	11	11
Low	11	11	11	11	11	11	11	11
	N = 264							

SECTION IV

THE FINDINGS

The pupil test scores which resulted from the final experiment were first subjected to an analysis of variance in terms of six sets of scores: (1) total scores (audio information + visual information + audio-visual information); (2) visual information scores; (3) audio information scores; (4) audio-visual information scores; (5) visual + audio-visual information scores; and (6) audio + audio-visual information scores. Tables VII through XII summarize the results of the analyses of variance. (The error term used throughout was the within-groups mean square since the experimental design was considered to be a fixed model).

Table VII

Analysis of Variance - Total Scores

Source of Variation	Sums of Squares	df	Mean Square	F-ratio
Treatment T	941	3	314	2.77*
Ability Level L	26202	2	13101	115.94**
Grade G	1201	1	1201	10.63**
L x G Interaction	791	2	396	3.50*
L x T Interaction	757	6	126	1.12
G x T Interaction	645	3	215	1.90
L x G x T Interaction	622	6	104	92
Error	27135	240	113	

* Significant at the 5% level
** Significant at the 1% level

Table VIII

Analysis of Variance - Visual Information Scores

Source of Variation	Sums of Squares	df	Mean Square	F-ratio
Treatment T	133	3	44	2.00
Ability Level L	4138	2	2069	94.05**
Grade G	130	1	130	5.90*
L x G Interaction	84	2	42	1.91
L x T Interaction	142	6	24	1.09
G x T Interaction	104	3	35	1.59
L x G x T Interaction	103	6	17	.77
Error	5359	240	22	

* Significant at the 5% level
** Significant at the 1% level

Table IX

Analysis of Variance-Audio Information Scores

Source of Variation	Sums of Squares	df	Mean Square	F-ratio
Treatment T	52	3	17	.85
Ability Level L	3608	2	1804	90.20**
Grade G	131	1	131	6.55*
L x G Interaction	90	2	45	2.25
L x T Interaction	104	6	17	.85
G x T Interaction	59	3	20	1.00
L x G x T Interaction	94	6	16	.80
Error	4769	240	20	

* Significant at the 5% level
** Significant at the 1% level

Table X

Analysis of Variance-Audio-Visual Information Scores

Source of Variation	Sums of Squares	df	Mean Square	F-ratio
Treatment T	188	3	63	3.70*
Ability Level L	1224	2	612	36.00**
Grade G	89	1	89	5.24*
L x G Interaction	80	2	40	2.35
L x T Interaction	88	6	15	.88
G x T Interaction	85	3	28	1.65
L x G x T Interaction	122	6	20	1.17
Error	4193	240	17	

* Significant at the 5% level
** Significant at the 1% level

Table XI

Analysis of Variance - A-V + Visual Information Scores

Source of Variation	Sums of Squares	df	Mean Square	F-ratio
Treatment T	585	3	195	3.42*
Ability Level L	10707	2	5398	94.70**
Grade G	472	1	472	8.28**
L x G Interaction	322	2	161	2.82
L x T Interaction	343	6	57	1.00
G x T Interaction	339	3	113	1.98
L x G x T Interaction	367	6	61	1.07
Error	13736	240	57	

* Significant at the 5% level
** Significant at the 1% level

Table XII

Analysis of Variance - A-V + Audio Information Scores

Source of Variation	Sums of Squares	df	Mean Square	F-ratio
Treatment T	357	3	119	2.47
Ability Level L	9798	2	4899	102.06**
Grade G	472	1	472	9.83**
L x G Interaction	283	2	141	2.94
L x T Interaction	255	6	43	.90
G x T Interaction	173	3	58	1.21
L x G x T Interaction	335	6	56	1.17
Error	11422	240	48	

* Significant at the 5% level
** Significant at the 1% level

Although main effects F-ratios for solely audio and solely visual information scores were not significant, tables VII, X, and XI show that there were significant differences in the treatment means for the other scores analyzed. A significant interaction appeared in the experiment in the levels x grade factor for total scores.

In order to ferret out the sources of main effect differences, and to permit more precise and appropriate tests of predictions, orthogonal comparisons of main effects means were made. These comparisons are summarized in tables XIII through XVIII.

Table XIII

Orthogonal Comparisons of Treatment Means - Total Scores

Source of Variation	Treatment Means				
	A→V 56.70	V→A 55.59	A-V (Pause) 58.98	A-V 60.41	
	SS	% of treatment SS due to source	df	MS	F-ratio
C_1 : (A→V)-(V→A)	40	4%	1	40	.35
C_2 : (AVP)-(AV)	67	7%	1	67	.59
C_3 : (Cont. - Exp.)	834	89%	1	834	7.38**
Treatments	941	100%	3	314	2.77*
Error term	27135		240	113	

* Significant at 5% level
** Significant at 1% level

Table XIV

Orthogonal Comparisons of Treatment Means -
Visual Information Scores

Source of Variation	Treatment Means				
	A→V 20.35	V→A 20.33	A-V (Pause) 21.79	A-V 2.73	
	SS	% of treatment SS due to source	df	MS	F-ratio
C_1 : (A→V)-(V→A)	.02	negligible	1	.02	.0009
C_2 : (AVP)-(AV)	.12	negligible	1	.12	.005
C_3 : (Cont. - Exp.)	132	almost 100%	1	132	6.00*
Treatments	133	100%	3	44	2.00
Error term	5359		240	22	

* Significant at 5% level
** Significant at 1% level

Table XV

Orthogonal Comparisons of Treatment Means - Audio Information Scores

Source of Variation	Treatment Means				
	A→V 17.79	V→A 17.00	A-V (Pause) 18.23		A-V 17.80
	SS	% of treatment SS due to source	df	MS	F-ratio
C_1 : (A→V)-(V→A)	20	38%	1	20	1.00
C_2 : (AVP)-(AV)	6	12%	1	6	.30
C_3 : (Cont. - Exp.)	26	50%	1	26	1.30
Treatments	52	100%	3	17	.85
Error term	4769		240	20	

* Significant at 5% level
** Significant at 1% level

Table VXI

Orthogonal Comparisons of Treatment Means - Audio Visual Information Scores

Source of Variation	Treatment Means A→V 18.50	V→A 18.26	A-V (Pause) 19.50		A-V 20.36
	SS	% of treatment SS due to source	df	MS	F-ratio
C_1 : (A→V)-(V→A)	5	2%	1	5	.29
C_2 : (AVP)-(AV)	25	14%	1	25	1.47
C_3 : (Cont. - Exp.)	156	84%	1	156	9.18**
Treatments	186	100%	3	63	3.70*
Error term	4193		240	17	

* Significant at 5% level
** Significant at 1% level

Table XVII

Orthogonal Comparisons of Treatment Means - Visual + Audio - Visual Information Scores

Source of Variation	Treatment Means				
	A→V 38.74	V→A 38.59	A-V (Pause) 40.98		A-V 42.09
	SS	% of treatment SS due to source	df	MS	F-ratio
C_1 : (A→V)-(V→A)	1	negligible	1	1	.02
C_2 : (AVP)-(AV)	40	7%	1	40	.70
C_3 : (Cont. - Exp.)	544	93%	1	544	9.54**
Treatments	585	100%	3	195	3.42*
Error term	13736		240	57	

* Significant at the 5% level
** Significant at the 1% level

Table XVIII

Orthogonal Comparisons of Treatment Means - Audio + Audio - Visual Information Scores

Source of Variation	Treatment Means				
	A→V 36.33	V→A 85.26	A-V (Pause) 37.48		A-V 38.33
	SS	% of treatment SS due to source	df	MS	F-ratio
C_1 : (A→V)-(V→A)	38	10%	1	38	.79
C_2 : (AVP)-(AV)	24	7%	1	24	.50
C_3 : (Cont. - Exp.)	295	83%	1	295	6.14*
Treatments	357	100%	3	119	2.47
Error term	11422		240	48	

* Significant at the 5% level
** Significant at the 1% level

The graph of levels x grade interaction effect that showed up in the total scores indicates quite clearly that the high ability 8th and 9th graders scored equally well. (See figure) The low ability 8th and 9th graders' scores were also fairly equal. The average ability groups' scores from the two grades, however, were quite different.

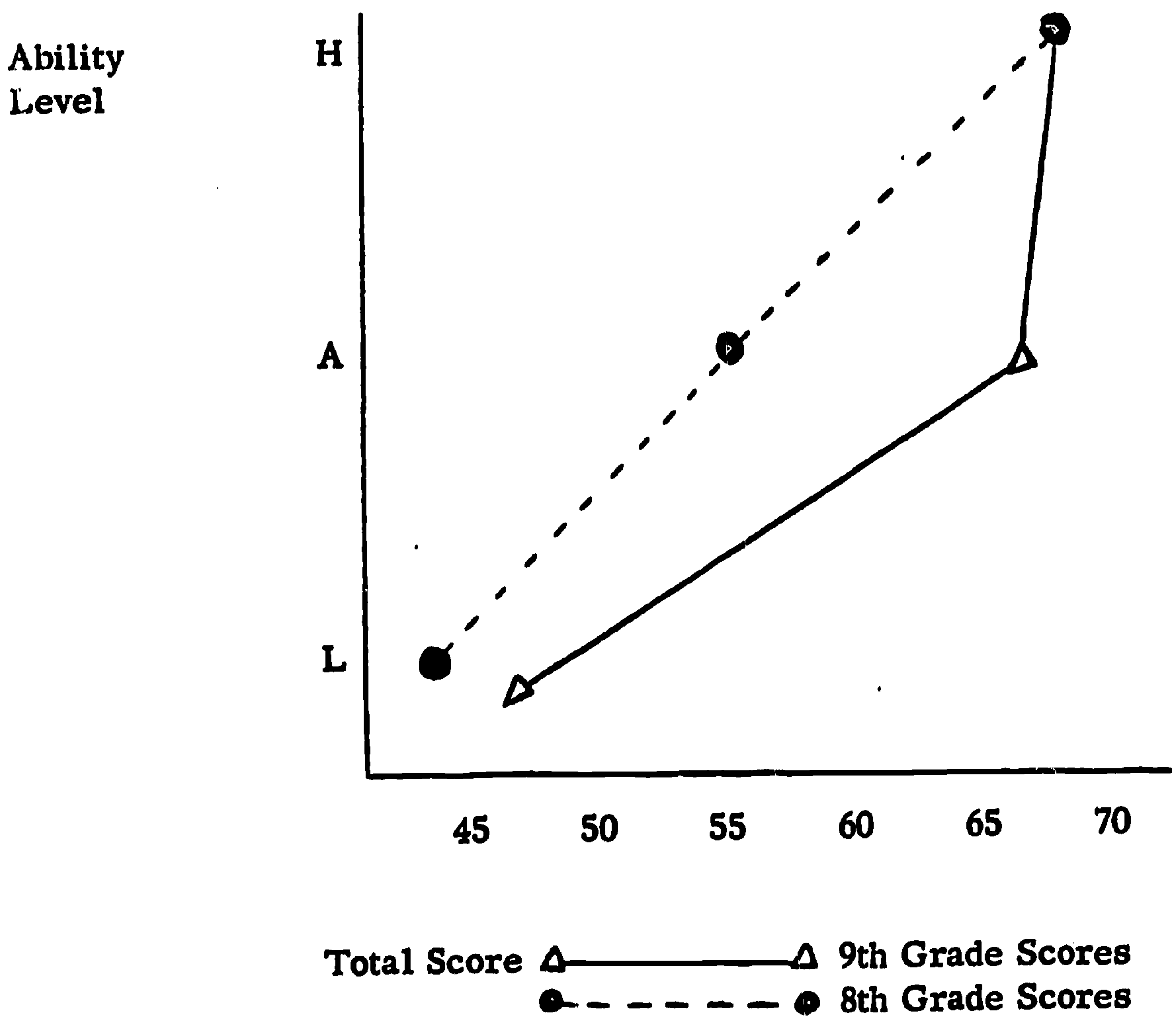


Figure 1 - Levels x grade interaction effect - Total Scores

Discussion

From the analyses of variance of treatments it is quite clear that the addition of ability level as a factor was very effective in increasing the precision of the final experiment in comparison to those which were first conducted. In every case, no matter what the source of information (solely audio, solely visual, or a combination of audio-visual), pupil performance was largely tied to ability. The ability factor thereby accounted for a large segment of the variability as reflected in the mean squares.

The guidance provided by the pilot study and preliminary experiments is suggesting alternative hypotheses to be tested, proved very useful in that planned comparisons could be made which supported two of the hypotheses. For example, the pilot study results led to alternative hypothesis one: Simultaneous audio-visual messages would prove superior over sight sound separation. The orthogonal comparisons, stemming from the hypothesis, showed that even where overall F-ratios accross all experimental and control treatments was not sufficiently high to reject null at the 5 per cent level of confidence, control groups (simultaneous AV) scores were significantly higher than experimental groups (sight-sound separation scores in all save the solely audio information scores.

Every orthogonal comparison between control groups, furthermore, supported the second alternative hypothesis that the two control modes (AV pause and A-V) would not perform differently; this in spite of the fact that several of the overall F-ratios were significant. The result also tends to give additional support to alternative hypothesis one since the control modes have simultaneous audio-visual messages in common but differ in the length of the lesson presentation. (If length of time in the lesson had affected the controls differently, using their scores in combination to check hypothesis one would have been a questionable procedure).

Limitation of the study in terms of population sampled, and the particular materials used in the study leaves several unanswered questions. For instance, would other age groups perform similarly with respect to the audio-visual sequence modes used? Are the confusing results regarding the originally predicted redundancy cueing effect a result of the materials variable or other uncontrolled factors? These questions would suggest a need for new experiments which consider hypothesis one with differing population. The questions also point out a need to study the problem of redundancy as a cueing effect using a variety of randomly selected audio-visual lessons.

SECTION V

SUMMARY AND CONCLUSIONS

As the study was originally conceived, consideration of the Broadbent model of perception and audio-visual experiments on cueing led to the proposal of three hypotheses with the following implications:

1. Whether an audio-visual lesson is largely audio informative or visual informative, sight-sound separated lessons will prove superior to simultaneous sight-sound lessons.

2. If an audio-visual lesson is largely visual informative (audio redundant), an audio cueing effect will make a sight-sound separated A→V lesson superior to one which was presented as V→A.

3. If an audio-visual lesson is largely audio informative (visual redundant), a V→A cueing effect will make a sight-sound separated V→A lesson superior to an A→V lesson.

The pilot study experiments produced results regarding hypothesis one which indicated that its reverse might be true. The preliminary experiments also appeared to support hypothesis three, that visual redundancy might produce a cueing effect making an V→A sequence superior to A→V. The logical inverse hypothesis two, which stated that audio redundancy should produce an audio cueing effect making A→V mode superior to V→A, was not supported. The final experiment was, therefore, developed primarily to test alternative hypotheses which reflected these ideas:

1. Pupils in the experiment would acquire more information from lessons that are presented with simultaneous sight and sound than from lessons which separate sight and sound.

2. The amount of information acquired by students who receive an A-V lesson slide-sound lesson in the ordinary fashion (picture with sound followed by picture with sound), would be about equal to such a lesson which includes brief no picture, no sound, interludes between the information frames.

3. When a lesson is largely audio informative, with visuals repeating information already found in the audio, the V→A presentation would prove superior to A→V.

The results of the final experiment, with the particular populations who were involved, support alternative hypotheses based on statements one and two but not number three.

Conclusions cannot be drawn regarding the reasons why the original hypothesis which predicted superiority of sight sound separation had to be rejected in favor of the reverse hypothesis. Several possibilities suggest further research, however. It is entirely conceivable, for example, that the Broadbent theory is correct but that human attention switches so rapidly from one communication channel to another that any attempt to force an individual into an externally regulated pattern reduces, rather than enhances, information acquisition. It may also be that the Broadbent theory is incorrect and that people do perceive information from several communication channels at once. The results of the study neither support nor refute these two notions.

In either event, however, the research which was conducted suggests very strongly that in terms of practical use with audio-visual materials, sight-sound separation is not an effective method. If the second possibility suggested is true--that the Broadbent theory is incorrect--then obviously sight sound separation, as a way of developing more informative audio-visual materials for children like those who took part in the experiment, will not work. But even if the first possibility is ture--that Broadbent is right, but that human attention switches very rapidly from one communication channel to another--it would appear that any attempt to take advantage of the phenomenon through artifical sight-sound separation of audio visual presentations will be met with frustration.

An accurate Broadbent theory would indicate that continuation of audio-visual materials experiments with attention focusing and cueing may be fruitful. Whether redundancy, either audio or visual, produces a cueing effect was not clearly answered by the results of the experiments, however. One of the pilot study experimental lessons, in which the visuals were redundant to a largely audio informative lesson, seemes to support the hypothesis that the V→A mode would be superior to A→V. The final experiment did not bear out the same hypothesis. Further attention may need to be given to the nature of the audio-visual presentation in terms of the percept source; whether largely audio, largely visual, or a mixture of the two. The confusing and inconclusive results regarding this kind of cueing effect could be due to the inability of the research accomplished in this study to control adequately the information source factors.

Experimental "Fall-Out"

The concluding experiment brought out some points which had not been singled out specifically for study. These factors, however, may be of interest to anyone who wishes to bring about a better use of audio-visual materials.

The ability levels x grade interaction effect and significant ability level and grade differences found would suggest that the common practice of using audio-visual lessons with several grades and with pupils who vary widely in ability is an inefficient method for both pupils and teacher. Some pupils may learn little from a given lesson; and the teacher, not knowing beforehand the behavioral objectives which can be accomplished by a given audio-visual lesson, may misuse it and thereby waste valuable teaching time. The experiments imply that the effective use of audio-visual materials requires that they, and also tests which evaluate the knowledge which pupils are to gain from them, should be pre-tested in terms of teaching objectives before they are put in general use in the schools. Such evaluation could be accomplished in several ways; but a practical method to do this, which divides responsibility between the people who produce audio-visual materials and the school consumers, might be as follows:

1. Grade level studies and trials to determine the grade norms--conducted by the companies which produce the materials before distribution.

2. Ability level and local test norms--conducted by the research or curriculum development departments of the school divisions which use the materials.

Finally, the research conducted demonstrated the gap which may occur between the findings of basic psychological research and developmental research which looks at theory in practice. The difficulty, however, is not unique to the behavioral sciences--developmental engineers are often faced with the same problem when they attempt to research ways to put the theories and findings of the national sciences into practice. The need for continued study of audio-visual teaching aids based upon theory of human perception is clearly indicated.

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